

climate change initiative

→ CLIMATE MODELLING USER GROUP

WP5 Adaptation of community climate evaluation tools for CCI

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The aims of WP5 (WP5.1-5.4, 5.6, 5.7) are:

- Exploit CCI and CCI+ data for evaluation of earth system models (ESMs)
- Enhance the **ESMValTool** with additional diagnostics and performance metrics for the evaluation of models with ESA CCI and CCI+ data
- Enhance use of ESA CCI and CCI+ data for climate model evaluation in the Climate Model Intercomparison Project (CMIP)
- Make a substantial contribution to the CMIP Phase 6 (**CMIP6**)
- Maintain and extend **Climate Monitoring Facility** (CMF) (database)
- Support ECV projects in processing and uploading their data to the **obs4MIPs** database



Scientific questions to be addresses in WP5

1. How well can state-of-the-art ESMs simulate climatological mean, variability and trends in selected ECVs?
2. What is the progress achieved in CMIP6 compared with CMIP5 in selected ECVs?
3. Are the new ESA CCI data complementing and changing global and regional model evaluation and benchmarking?



International ESMValTool development team

- 19 funded projects
- 63 institutions
- 203 developers

Righi et al., 2020

Technical overview

Eyring et al., 2020

Large-scale diagnostics

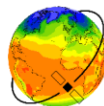
Lauer et al., 2020

Diagnostics for emergent constraints and future projections

Weigel et al., 2021

Diagnostics for extreme events, regional and impact evaluation

scientific documentation



ESMValTool

Earth System Model Evaluation Tool

- Tool for fast and easy routine **evaluation and analysis** of Earth system models including provenance records for all results (**traceability and reproducibility**)
- Well-established analysis based on **peer-reviewed literature**
- Many diagnostics and performance metrics covering **different aspects of the Earth System** (dynamics, radiation, clouds, carbon cycle, chemistry, aerosol, sea-ice, etc.) and their interactions
- Extensive **documentation** (user guide, peer-reviewed papers)
- Support for production of a subset of figures of the **IPCC WGI AR6**

<https://www.esmvaltool.org/>





ESA CCI datasets implemented into ESMValTool

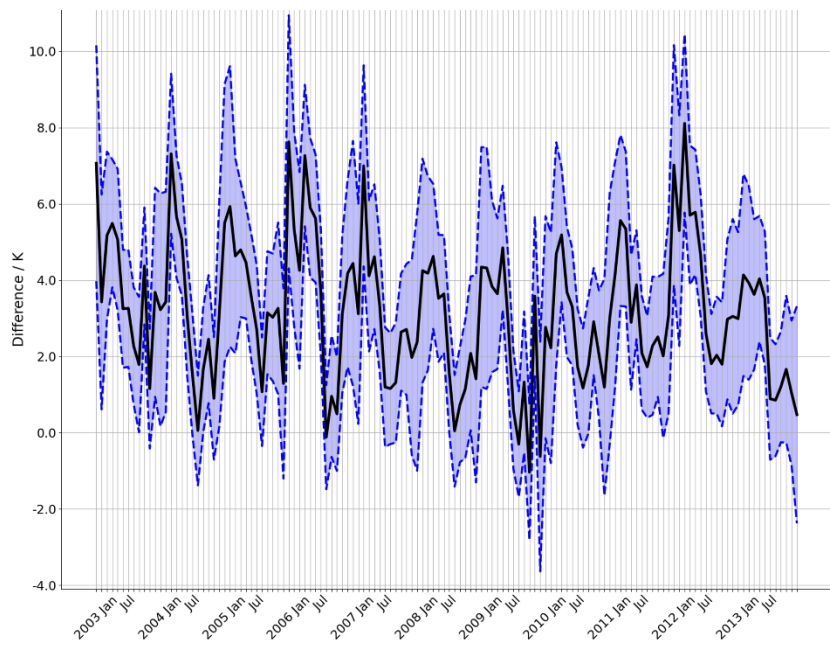


Dataset	Variable(s)	Resolution	Years
Aerosol	od550aer, od870aer, od550lt1aer, abs550aer	1°x1°	1997-2011
Cloud	clivi, clt, clwi, rlut , rlutcs , rsut , rsutcs	0.5°x0.5°	1982-2016
Fire	burntArea	0.25°x0.25°	2005-2011
Greenhouse Gases	xco2, xch4	5°x5°	2003-2016
Ozone	tro3, tropoz, toz	1°x1°	1997-2010
Land Cover	lccs_class: grassNcropFrac, shrubNtreeFrac	300 m	2000, 2005, 2010
Land Surface Temperature	ts	0.1°x0.1°	2003-2018
Ocean Colour	chl	4 km	1998-2020
Sea Ice	sic	25 km	1992-2008
Sea Surface Temperature	tos	0.5°x0.5° (0.05°x0.05°)	1982-2019
Sea Surface Salinity	sos	25 km (50 km)	2010-2018
Soil Moisture	sm	0.25°x0.25°	1988-2005
Water Vapour	prw	0.5°x0.5°	2003-2017





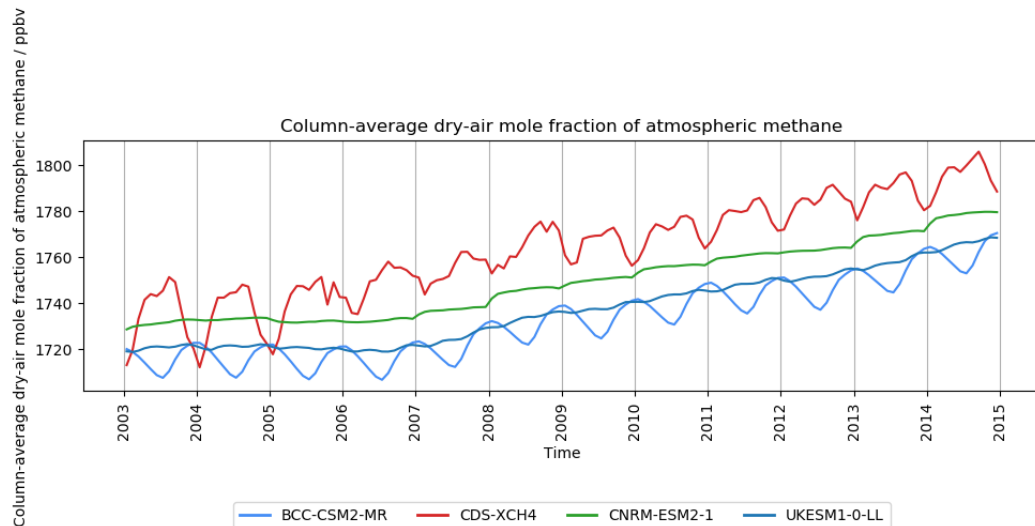
Land surface temperature



- L3C single sensor monthly data (Aqua MODIS)
- Mean of the day time, and night time overpasses
- Comparison of ESA CCI LST to multiple historical ensemble members of CMIP models
- Over a defined region for monthly values of the land surface temperature
- Output: mean difference of CCI LST to model average LST, with a region of +/- one standard deviation of the model mean LST given as a measure of model variability



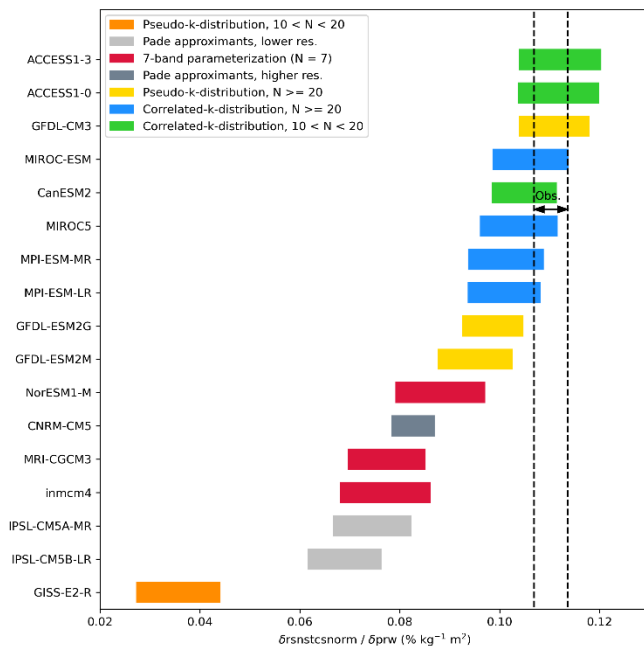
Long-lived GHGs (XCH4)



- Global mean (area weighted) monthly mean time series of XCH4 from different datasets from 2003 to 2014 (user-defined region)
- Annual cycle of XCH4 for different datasets (observations and model simulations) for a specific user-defined region and time period



Water Vapour

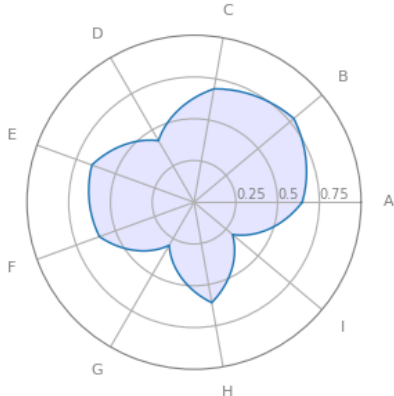


- Comparison of models with different schemes for water vapor short wave radiance absorption with the observations. The ESA CCI CDR-2 data are used for water vapour in addition to CERES-EBAF radiances.
- Analysis of specific humidity at the cold point tropopause height. Diagnostic will use ESA CCI water vapour data CDR-4 once available.
- Zonal means of specific humidity at pressure levels between 250 and 1 hPa and at cold point tropopause height. ESA CCI water vapour data CDR-3 will be used once available.



Sea Surface Salinity

sos correlation
MPI-ESM1-2-HR vs ESACCI-SEA-SURFACE-SALINITY_V1



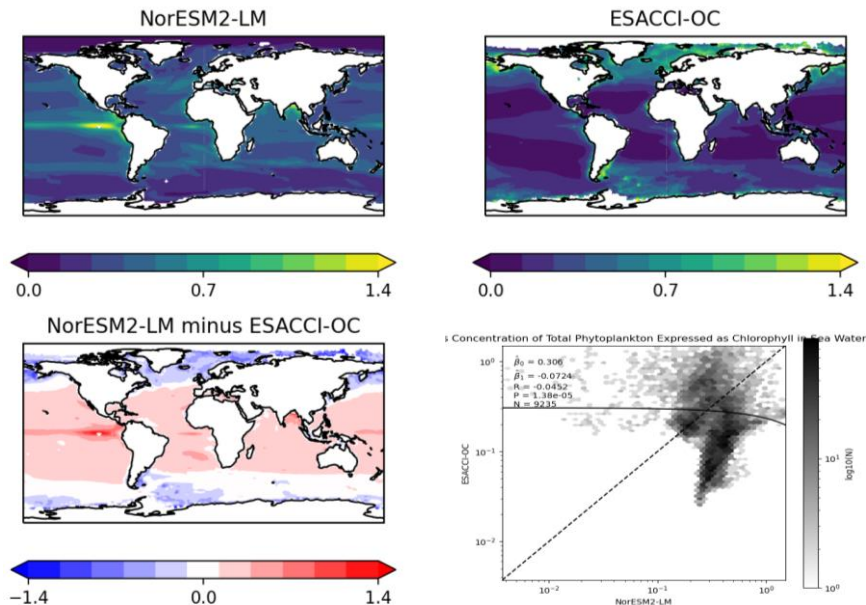
- | | |
|--|-------------------------------|
| A Arctic Ocean | F North Pacific Ocean |
| B Indian Ocean | G South Atlantic Ocean |
| C Mediterranean Sea - Eastern Basin | H South Pacific Ocean |
| D Mediterranean Sea - Western Basin | I Southern Ocean |
| E North Atlantic Ocean | |

Comparison of regional averages of sea surface salinity with ESACCI-SEA-SURFACE-SALINITY v1 or v2

- Timeseries for each region
- Radar plot showing correlation of average sea surface salinity for multiple regions with the observations



Ocean Colour



- Comparison of ocean surface chlorophyll from CMIP models to ESA CCI ocean colour chlorophyll
- Merged sensor geographic monthly L3S chlor_a data and monthly model data
- Multiple models and different observational versions can be used



CMIP6 evaluation - Southern Ocean clouds

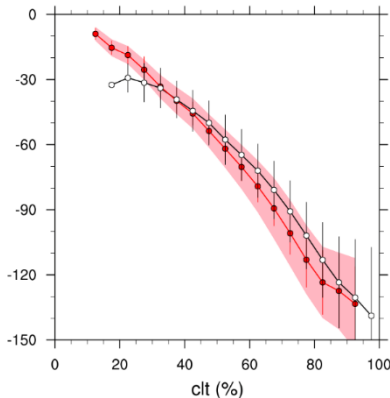
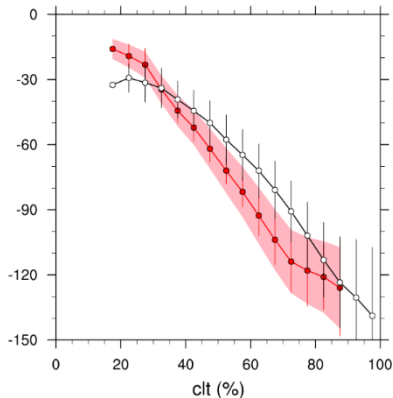
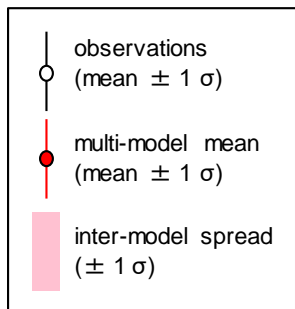


Shortwave cloud radiative effect ($W m^{-2}$)

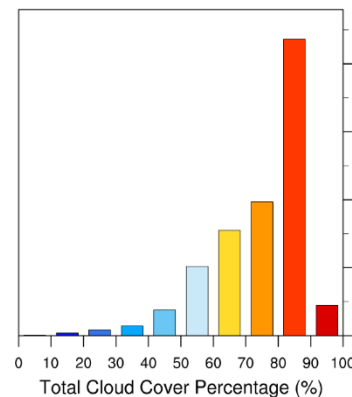
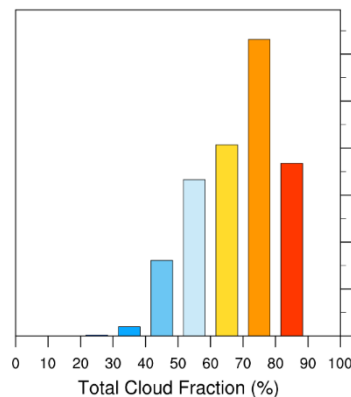
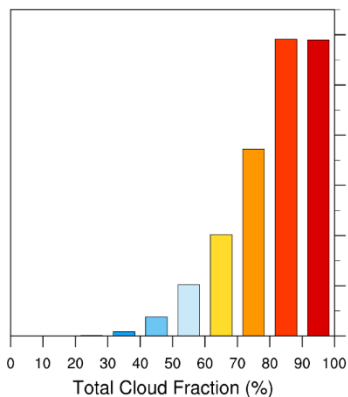
Total cloud cover (%)

CMIP5 MMM

CMIP6 MMM



OBS



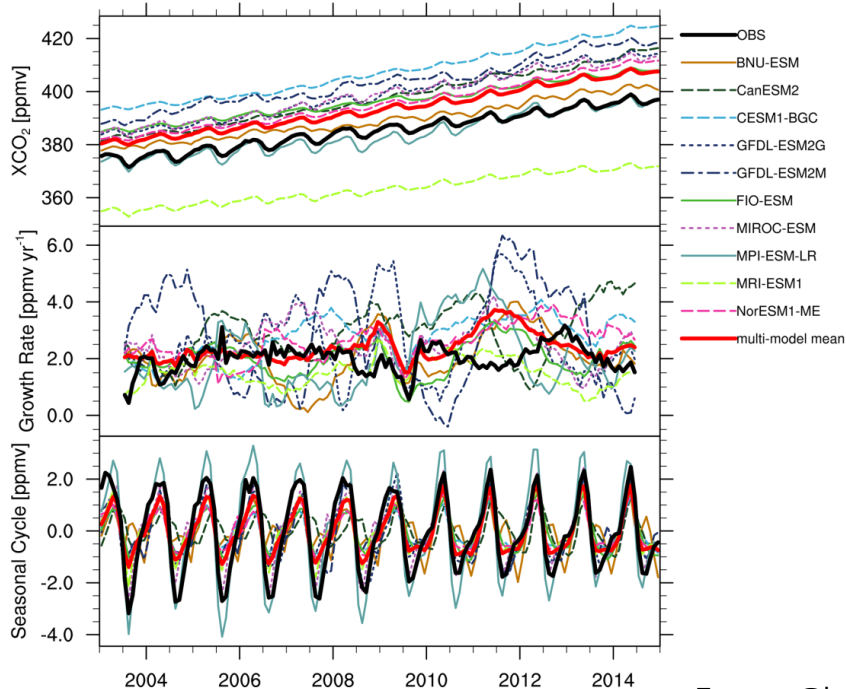
From: Lauer et al. (in prep.)

- Observations: CERES-EBAF, ESACCI-CLOUD
- Reduced shortwave cloud radiative effect for given total cloud fraction
- Improved agreement of CMIP6 MMM with observations compared with CMIP5
- Increased frequency of high total cloud amounts in CMIP6 compared with CMIP5
- Improvement of "too few, too bright problem" in CMIP6

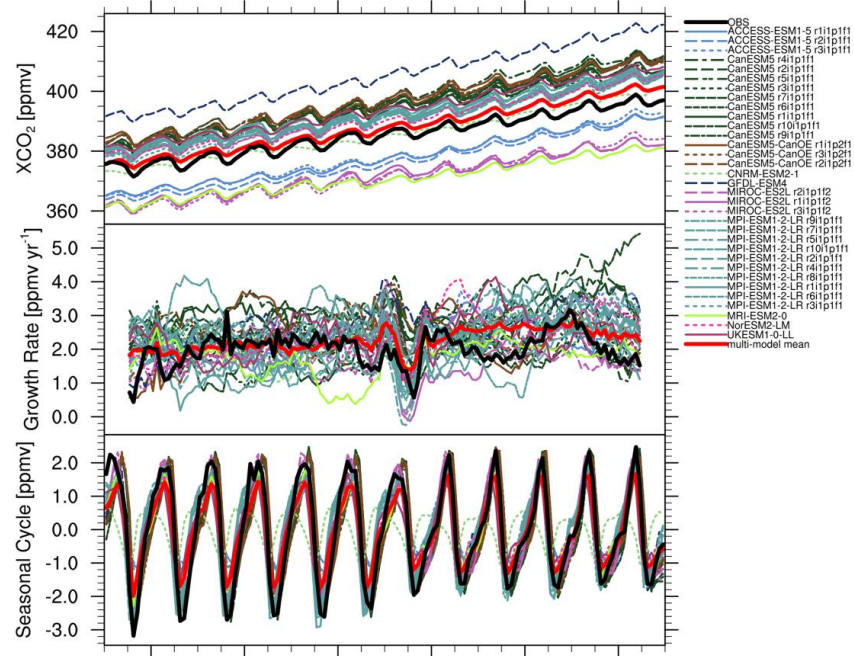




CMIP5



CMIP6

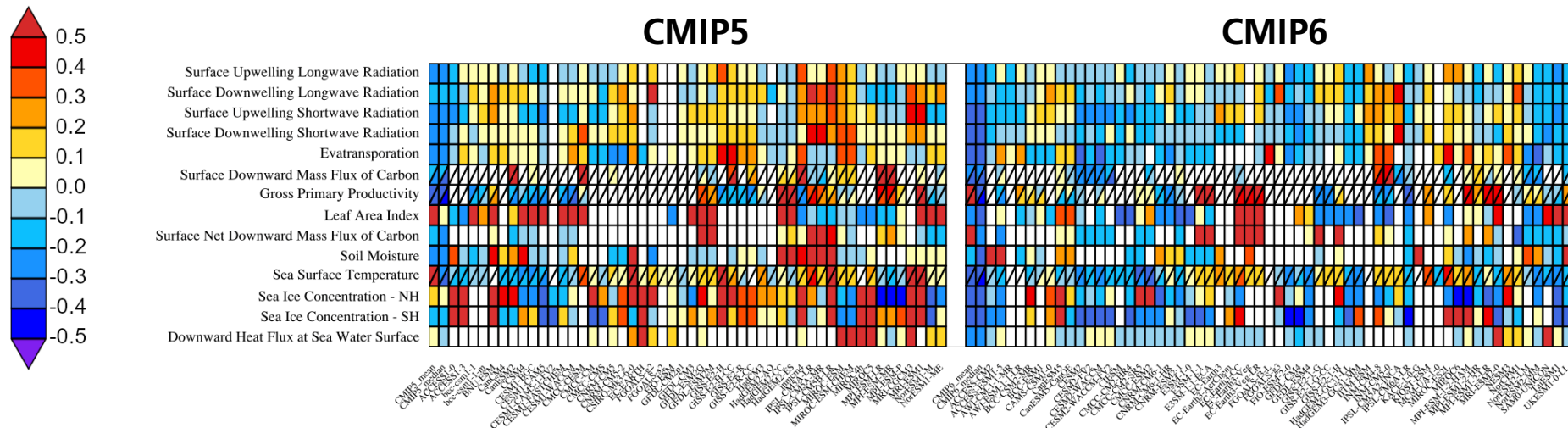


From: Gier et al. (2020)





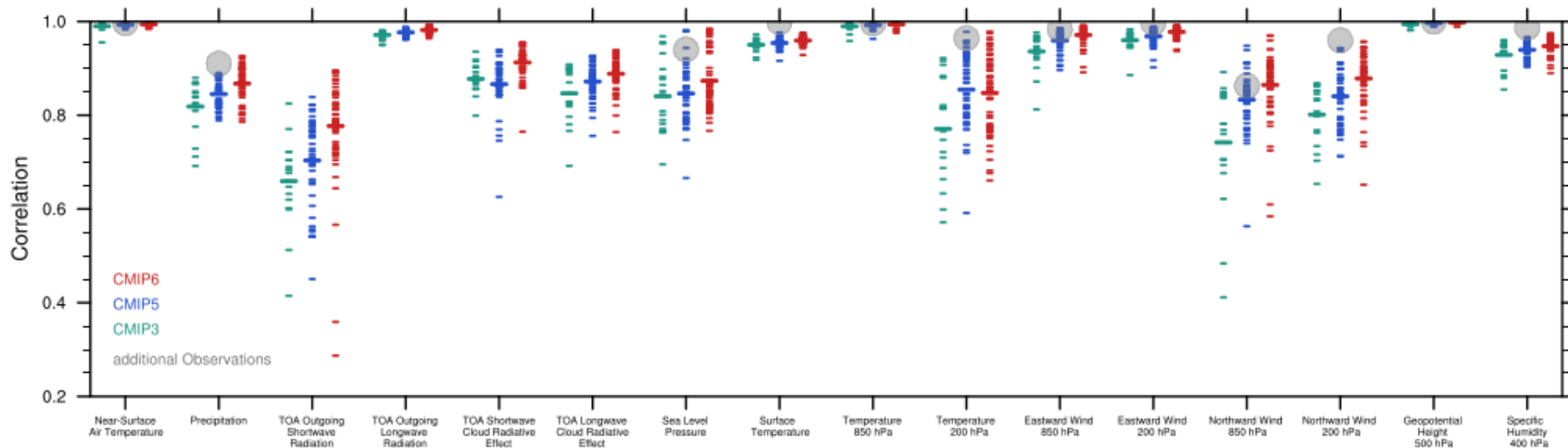
Relative model performance (RMSD)



From: IPCC AR6, Chapter 3 (fig. 42)



Pattern correlations



From: IPCC AR6, Chapter 3 (fig. 43)



- ESMValTool development is growing
- Current release: v2.3 (July 2021)
- Evaluation of CMIP6 models with ESA CCI data ongoing
- Development of the ESMValTool will continue beyond the end of CMUG



<https://www.esmvaltool.org/>

